A SINKING FEELING | EDUCATOR

Links to Next Generations Science Standards |

MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

Links to Common Core Standards |

CCSS.ELA-LITERACY.RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually.

S T E M

Supplement Video |
https://www.youtube.com/watch?v=RGEkyI6H4i0
https://vimeo.com/155579978 (password: exploration)

Pacing | 2 - 3 class periods (45 minutes each)

Background Needed | basic understanding of density, surface area, and buoyancy

Assessment | Extended Response rubric provided

Materials/Resources |

- Large clear container(s) to fill with water (test tank)
- Golf ball, salt and large container/beaker
- Any combination of the materials below:
- Tape (duct, masking, electrical), rubber bands, string
- Modeling clay, Play-Doh
- Airtight containers (sealed straws, ketchup packets, small water bottles, etc)
- Cork, aluminum foil, styrofoam
- Cardboard
- Sand, small pebbles, pennies, washers, paper clips
- Other common household supplies

Overview

This learning module provides students with an introduction to the Exploration Vessel *Nautilus* and remotely operated vehicles (ROVs) as platforms for exploration. Students will use the "Think, Try, Make, Redesign" model to build a neutrally buoyant model.

Objectives & Learning Outcomes

- Students will understand the engineering design process.
- Students will be able to discuss surface area and density as well as their relationships to buoyancy.
- Students will understand the difference between positive, negative, and neutral buoyancy.

Guiding Questions

- What causes some objects to float and others to sink?
- What effects do different variables (e.g., surface area, mass) have on your design?
- What factors contribute to a working model?
- How do the concepts explored in this lesson apply to a real scientific expedition?

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Set The Stage!

Before students arrive, stage the following demonstration, but plan to save the discussion until after the activity.

Students may question what's going on but building a neutrally buoyant vehicle may give them new understanding of what they're seeing.

Place a golf ball in a large beaker full of salt water. Dissolve enough salt into the water so that the golf ball hovers somewhere in the middle of the water without touching the bottom of the beaker or breaking the surface of the water.

Activity/Tasks

Students will:

- collect materials as a group,
- collaborate on a design,
- discuss design and begin construction on their model,
- test, build, record, and discuss results as a group,
- share results with class,
- refine and design improved model design.

Educator: Lesson Procedure/Directions

✓ **LESSON SET-UP |** Teachers should implement their own classroom policy for lab safety when students are acquiring materials. The materials needed for this lesson include:

- ☐ Clear tubs or tanks filled with water for each group or a larger tank for the entire class
- ☐ A variety of construction supplies for the students to use to build their model vehicles. Suggested supplies include any of the following:
    - ☐ Non-water based clay
    - ☐ Airtight containers- Ketchup/soy sauce packets, film canisters, plastic straws that can be sealed airtight and filled with air, water, sand, rocks etc (air to liquid ratio within the container can be manipulated)
    - ☐ Paperclips, binder clips
    - ☐ Washers
    - ☐ Cork
    - ☐ Aluminum Foil
    - ☐ Cardboard
    - ☐ Sand, small pebbles, ballast material
    - ☐ Large clear container to fill with water
    - ☐ String
    - ☐ Tape (Duct, Masking, Electrical, Etc)
    - ☐ Rubber bands
    - ☐ Other common household supplies

Pre-Lab Questions

1. Why do we explore the ocean?
   - ✓ **Possible answers:** Make new discoveries and gain a better understanding of ecosystems and biological/chemical/ geological processes, coming across new natural and cultural resources, salvage & shipwrecks

2. What technology and tools do we use?
   - ✓ **Possible answers:** submersibles (ROV, HOV, AUV), research ships, SONAR, satellites, current meters, water samplers, drop cameras

3. What are some limitations in exploring the ocean?
   - ✓ **Possible answers:** depth, funding, weather, access to technology, permits

Define the following terms:

Students will be able to understand and define the following concepts by completing this lesson.

Buoyancy

- ✓ The ability or tendency of an object to float when placed in a fluid

Positively Buoyant

- ✓ When the weight of the fluid that an object displaces is more than the weight of the object.

Negatively Buoyant

- ✓ When the weight of the fluid that an object displaces is less than the weight of the object.

Neutrally Buoyant

- ✓ When the weight of the fluid that an object displaces is equal to the weight of the object. The object neither floats or sinks. You can describe neutral buoyancy as "flinking" neither floating or sinking.

Extensions & Adaptations

Introductory | Students can investigate the basics of buoyancy by building simple boats to carry pennies on the surface of the water. Students can measure surface area and calculate projections of buoyancy. *Reference:* - http://www.pbs.org/parents/adventures-in-learning/2014/05/design-penny-boat/

Advanced | Students can evaluate the cost/ benefits of their model by calculating the cost of building their model based on a pricing list provided by the teacher. Students could then use costs to make a formal proposal requesting funding by a government agency or private company for scientific research.

Ask students to calculate the buoyancy of each design piece before assembling. Use this as a link to material properties.

Extensions & Adaptations

More Advanced |

Cardboard Kayak | Students can create a full-sized kayak out of cardboard supplies and test them in a pool or body of water.

Build a Submarine | Students can also go through the design process to create submarines with changing buoyancies, allowing them to move up and down through the water column.

Student Procedure

1. Read worksheet introduction and complete pre-lab questions
2. Collect materials as directed by your instructor.
3. Individually sketch design ideas & consult with group
4. Discuss the design and begin construction.
5. Test your build's buoyancy in the test tank and record your results.
6. Discuss the test results as a group AND Share results with class.
7. Refine your design by sketching improvements.
8. Rebuild your refined design.
9. Retest the improved design's buoyancy and record your results.
10. Write detailed paragraph describing design process, using key terms in explanation of modifications and drivers of success.

Student Data

- ✓ Emphasize the importance of designing and working as a team. Drawings should be done before building begins. You may wish to assign one collaborative sketch per group or individual sketches from each team member.
- ✓ If there are groups struggling and in need of additional support, help identify parts of their models that can be modified (e.g., surface area, shape, pockets of air, amount of positively buoyant and negatively buoyant materials).

Student Analysis

- ✓ Students should be able to describe their results and apply key terms to why their models ultimately because neutrally buoyant or did not become neutrally buoyant.
- ✓ After completing the lesson, return to the neutrally buoyant gold ball demonstration. Have students use the term "buoyant" (positively/neutrally/negatively) to describe the ball on the water.
- ✓ Student prompts: What factors affect buoyancy? How does changing the fluid medium affect the buoyancy of an object? Why is the golf ball hovering in the water? How can you manipulate the water solution to make the golf ball go up or down within the container?
- ✓ Ask an Expert: assist students in connecting their work to careers associated with the Nautilus Exploration Program (e.g., ROV engineer)

A SINKING FEELING | STUDENT

THINK About It!

- What materials will always float or will sink?
- What effects do different variables (e.g., surface area, mass) have on your design?
- What factors contribute to a working model?
- How do the concepts explored in this lesson apply to a real scientific expedition?

Challenge: Your challenge is to build a neutrally buoyant model vehicle which will hover in the water column using only the supplies provided to you.

Introduction | To successfully complete this challenge, you will explore the principles of buoyancy- what makes something sink or makes it float? An object that floats in water is said to be positively buoyant, an object that sinks is negatively buoyant, and an object that is fully submerged without sinking completely is neutrally buoyant. Greek scientist Archimedes (BC 287 - BC 212) discovered that the buoyant force on an object in liquid is equal to the weight of the liquid displaced. When the weight of an object is less than the weight of the fluid displaced, it will float. When the weight of an object is greater than the weight of the fluid displaced, it will sink. When these values are equal, neutral buoyancy is achieved. These principles are utilized by engineers when designing a variety of oceanographic tools and vessels such as Remote Operated Vehicles (ROVs), ships, and submarines.

Pre-Lab |

1. Why do we explore the ocean?

2. What technology and tools do we use?

3. What are some limitations in exploring the ocean?

NAUTILUS NEWSFLASH

The Nautilus Exploration Program uses two remotely operated vehicles (ROVs) *Hercules* and *Argus* to explore the ocean. *Argus* is a negatively buoyant vehicle that is suspended above *Hercules* during dive operations. *Argus* provides stabilization and light for *Hercules* to operate. *Hercules'* buoyancy is adjusted for each mission by adding or removing weight to achieve a safety margin of positive buoyancy. *Hercules* must be near neutral buoyancy to perform delicate operations and maneuvers. This includes the collection of rocks, mud, artifacts and living organisms in addition to the high definition video recorded. The *Nautilus* uses these two robots to explore the Earth's oceans and carry out scientific expeditions across the globe. For a tour of these vehicles check out this video: http://nautl.us/1VflKWx.

Vocabulary |

Buoyancy:

Positively Buoyant:

Negatively Buoyant:

Neutrally Buoyant:

Archimedes Principle:

Ballast:

Materials:

Each group will have a test “tank” full of water
Shared class supply depot of construction materials

Design Procedure:

1. Collect materials as directed by your instructor.
2. Sketch out your vehicle’s design.
3. Discuss the design and begin construction.
4. Test your build’s buoyancy in the test tank and record your results.
5. Discuss the test results as a group AND Share results with class.
6. Refine your design by sketching improvements.
7. Rebuild your refined design.
8. Retest the improved design’s buoyancy and record your results.

Design Sketch #1:

Label your build and the function of each part

Test Tank Trial 1:

(Take notes on your vehicle’s performance and ideas that emerge. Guiding questions are in the margin)

Initial Design Debrief:

What worked and why?

What did not work and why?

What will you do in your second build?

Refined Design Sketch #2:
Label your build and the function of each part

Test Tank Trials:
(Take notes on your vehicle's performance and ideas that emerge)

Student Analysis:
Complete a paragraph describing your design process. Include what was successful, modifications made, and how they affected change. Correctly use the terms buoyancy, positively buoyant, neutrally buoyant, negatively buoyant, and ballast in your response. Choose a group representative who will report out to the class.

Refined Design Debrief:
How did my modifications change the performance? Did it complete the buoyancy challenge? What worked and why?

What did not work and why?

What did I learn?

Extended Response Rubric

OBJECTIVE	CRITERIA			
	4 Exemplary	3 Commended	2 Emerging	1 Developing
Content and Vocabulary |	Explanation uses appropriate vocabulary. Student is able to provide clear examples of the content or justify their response. Student is able to discuss application of the content. Response contains no content errors.	Explanation uses appropriate vocabulary. Student is able to provide some examples of the content or justify their response and is able to discuss application of the content. Response may contain minor errors that do not detract from overall understanding of the topic.	Student attempts to use appropriate vocabulary. Student attempts to provide some examples of the content or justify their response. Application of the content may be weak. Response may contain some errors.	Use of appropriate vocabulary is weak. Student does not attempt to provide examples of the content or justify their response. Application of the content is weak or nonexistent.
Language and Conventions |	Student produces clear and coherent writing in which the development, organization and style are appropriate to task, purpose and audience. Demonstrates an exemplary command of standard English conventions.	Student produces writing in which the development, organization and style are appropriate to task, purpose and audience. Demonstrates a command of standard English conventions; errors do not interfere with understanding.	Student produces writing in which some development, organization and style are appropriate to task, purpose and audience. Demonstrates a limited and/or inconsistent command of standard English conventions; errors may interfere with understanding.	Student produces writing in which there is limited development, organization and style appropriate to task, purpose and audience. Demonstrates a weak and/or inconsistent command of standard English conventions; errors interfere with understanding.
Total Score: ____________	**Comments:**			

How Large is Nautilus Nation?

Tracking the reach of Ocean Exploration Trust's education programs is essential in ensuring we are funded to continue making discoveries and inspiring the next generation of explorers.

Name: **My Community (City, State):**

Email Address:

School's Name:

Instruction date: **Grade level instructed:**

Subject area:

My education space is a...

- ❏ Classroom
- ❏ After school program / Club meeting
- ❏ Fair / Festival / Event
- ❏ Museum / Science Center
- ❏ Other. Tell us more:

Who did you engage in your teaching?

Students

Community Members

Select all the OET materials you used in your instruction:

- ❏ STEM Learning Modules. Which ones? ______________________________
- ❏ Digital Resource Library materials. Which ones? ______________________________
- ❏ Nautilus Live website: photo albums ☐ highlight videos ☐ live stream
- ❏ Meet the Team STEM mentor profiles
- ❏ Facebook (NautilusLive) ☐ Twitter (@EVNautilus) ☐ Instagram (@nautiluslive)
- ❏ Other. Tell us more: ______________________________

____

What made working with OET resources valuable to your instruction (select all that apply)?

- ❏ Hands-on activities ☐ STEM career connections
- ❏ Easy to use lessons ☐ Standards-based lessons
- ❏ Website resource access ☐ Real world application of curricula topics
- ❏ Excitement of cutting-edge discoveries / Unfamiliarity of deep ocean
- ❏ Another reason. Tell us more: ______________________________

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Using OET resources increased my confidence in teaching my science, technology, engineering, or math subjects.	☐ Yes	☐ No
OET provided me with helpful and relevant teaching resources.	☐ Yes	☐ No
Using OET resources increased my awareness of STEM careers.	☐ Yes	☐ No
If yes, how so? How can we improve?		

Please scan this document or snap a picture of it with your phone. Email the feedback or questions to education@oet.org. You can also submit feedback online: http://nautl.us/2cp3PNu

Thank You For All You Do!